

# DEPARTMENT OF ENERGY AND NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA) OPERATIONAL AND RESEARCH WEATHER PROGRAMS

For almost 60 years, the Department of Energy (DOE) and its predecessors, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), have established and supported meteorological operations and atmospheric research at the DOE field facilities. The need for meteorological services began in 1944 with the development, fabrication, and testing of atomic weapons and their accompanying national security and safety issues. Meteorological program requirements were subsequently augmented, starting in the late-1960's, by the passage of environmental protection legislation under the Clean Air Act, which is enforced by the Environmental Protection Agency (EPA) under 40 CFR enabling regulations, and reinforced by several DOE Orders that specify requirements for meteorological services to protect public health and safety and the environment. Consequently, a meteorological monitoring program has become an even more essential component of each DOE site. Moreover, the acquisition of quality-assured meteorological data and the provision of weather forecasting services is an important element of a DOE Integrated Safety Management System (ISMS). It significantly contributes to the implementation of site-wide personnel safety programs along with site evaluations. These evaluations include, but are not limited to the following: protection of facility workers and the public; development of Authorization Basis (AB) safety documentation; diagnostic and prognostic consequence assessment elements of an emergency management system; preparation of permits to support environmental compliance activities; and, impact analyses of construction and operation of projects and missions requiring National Environmental Protection Act (NEPA) determinations.



## OVERVIEW OF DOE AND NNSA OPERATIONAL METEOROLOGICAL PROGRAMS AND SUPPORTING RESEARCH

Recognition of the need for site-specific meteorological services began in 1944, with the development, fabrication, and testing of atomic weapons and their accompanying national security and safety issues. In response to this need, the Department of Energy (DOE) and its predecessors, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), and the current National Nuclear Security Administration (NNSA), have established and supported operational meteorological programs and atmospheric research projects at many DOE and NNSA field offices.

Operational meteorological program requirements were subsequently augmented, starting in the late-1960's, by the passage of environmental protection legislation under the Clean Air Act (CAA), enforced by the Environmental

Protection Agency (EPA) under 40 Code of Federal Regulations (CFR) enabling regulations, and reinforced by several DOE directives (e.g., DOE O 5400.1) that specify requirements for meteorological services to protect facility worker health and safety, public health and safety, and the environment. Since that time, the CAA has been amended on three occasions, each time including broader requirements, inclusive of stratospheric ozone protection regulations. Consequently, an effectively managed meteorological monitoring program has become an even more essential component of operations at each DOE and NNSA site.

Moreover, the acquisition of quality assured meteorological data, the provision of weather forecasting services, and the development of site-specific climatology from these meteorological programs is an important element of a DOE Integrated Safety Management System (ISMS) that significantly contributes to the implementation of site-

wide personnel safety programs and supports multiple evaluations. These evaluations include, but are not limited to the following:

- Protection of facility workers and the public;
- Development of nuclear and chemical safety documentation (e.g., Safety Analysis Reports);
- Diagnostic and prognostic consequence assessment elements of emergency management programs;
- Preparation of air and surface water permits to support environmental compliance activities; and,
- Impact analyses for construction, operation and decommissioning of projects, and missions requiring National Environmental Protection Act (NEPA) determinations.

DOE and NNSA continue to address their fundamental mission areas of national security, science and technology, energy security, and environmental clean up of cold war production sites. Meteorology and atmospheric science contributes to many of these

mission elements. Consequently, atmospheric science research programs and weather forecasting operations have been an integral part of DOE, NNSA and its predecessor agencies since World War II. Therefore it is vital to understand the nature of the atmospheric domain and its relationship to terrestrial, ocean, and other environmental domains. Understanding these relationships feeds into the reduction of uncertainties regarding climate change research.

DOE and NNSA administer programmatic activities throughout their various offices, such as the Office of Science (SC), Environmental Safety and Health (ES&H), the National Nuclear Safety Administration (NNSA), and Environmental Management (EM), in which each has some linkages to meteorology and atmospheric science. Some of these program offices are responsible for the management of scientific research programs, such as the National Atmospheric Release Advisory Capability (NARAC), Global Climate Change Research (GCCR), and various environmental cleanup activities at former DOE production sites. Additional activities at DOE and NNSA sites include support to daily operations and national defense programs; all of which require a fundamentally sound well-managed meteorological monitoring program.

Meteorological services at DOE and NNSA facilities range from the conduct of cutting-edge basic research to providing daily support to operational programs and construction projects. Some examples of research and development are investigations of potential global climatic change, radiation transfer mechanisms and cloud studies, lightning and thunderstorm studies, atmospheric chemistry, atmospheric tracer studies, and studies of atmospheric planetary boundary layer processes. Operational support programs include daily-customized

weather forecasting services, support to national defense projects and homeland security, onsite meteorological monitoring programs, climatological services, occupational health and safety program support, and emergency management program support.

Some DOE and NNSA sites maintain 24-hour weather watches for severe weather conditions that have the potential to impact site operations, damage property, or threaten lives. DOE-wide and NNSA-wide lightning safety initiatives, which are becoming integral elements of an Integrated Safety Management System (ISMS), are supported by DOE and NNSA operational meteorological programs (e.g., Nevada Test Site (NTS), Hanford, Savannah River Site (SRS), Idaho National Engineering and Environmental Laboratory (INEEL)).

A number of DOE and NNSA field offices and their associated sites and facilities cover large areas (e.g., INEEL, Oak Ridge Reservation (ORR), NTS, Hanford, and SRS). In addition, several DOE and NNSA sites are situated in areas of complex topography and heterogeneous surface characteristics (e.g., land-water interface), creating mesoscale conditions that locally influence onsite weather and more importantly, airflow trajectories associated with atmospheric transport and dispersion. This is why DOE originated a research program addressing Atmospheric Studies in Complex Terrain (ASCOT) during the eighties and early nineties to address emergency response issues in complex terrain environments at the various DOE sites.

For these reasons, and to ensure the protection of public health and safety and the environment, onsite meteorological monitoring programs have been, remain, and will always be an essential part of DOE and NNSA atmospheric science programs. Moreover, partnerships have been forged with other Federal agencies (i.e., Department of Commerce (DOC) via

its National Oceanic and Atmospheric Administration (NOAA)) to leverage research resources addressing complementary mission areas.

Some DOE and NNSA sites enhance the spatial resolution of the National Weather Service (NWS) observing network by taking standard surface and upper-air observations. Many of these sites are in remote areas where NWS and community weather observations would otherwise be limited. Weather observations taken at a few DOE and NNSA field sites are entered into the database via the NWS meteorological data distribution and display system. This distribution and display system interconnects field offices and serves as the distribution system for NWS meteorological products that are centrally produced by the National Centers for Environmental Prediction (NCEP). Some DOE and NNSA sites (e.g., NOAA Air Resources Laboratory (ARL)/Special Operations and Research Division (SORD), Las Vegas, NV) employ the NOAA Advanced Weather Information Processing System (AWIPS), as well as vertical profilers and meteorological monitoring networks.

An accidental release of radioactive, chemical, or biological toxic material into the atmosphere can have potentially serious health effects, as well as environmental consequences. Meteorological transport and dispersion processes play a key role in determining the fate of radioactive, chemical, or biological agents released into the atmosphere; including those resulting from malevolent acts. Consequently, a central theme within the DOE and NNSA community has been to protect public health, safety, and the environment on and around DOE and NNSA facilities by accurately measuring and characterizing the important local atmospheric processes necessary to characterize atmospheric transport and dispersion.

In recognition of the aforementioned

needs and requirements, DOE and NNSA have established and continue to support onsite meteorological monitoring programs since the commissioning of an operational meteorological program in 1944 at Hanford. Each meteorological program contributes to the support of emergency management programs and focused towards the protection of the environment and the safety and health of the onsite work force and the public. In addition, research on the modeling of the transport, dispersion, deposition, and resuspension of radioactive, chemical, and biological agent materials is undertaken to refine the transport and dispersion models used in these endeavors. New remote sensing techniques are being developed, such as the "Best" Aircraft Turbulence probe at the ARL Field Research Division (FRD), in Idaho Falls, ID. Onsite weather forecasting services, each tailored specifically for the special operational and emergency management requirements at each DOE and NNSA site, provide necessary support to the safety and health programs designed to protect site personnel, the public, and the environment.

Over the years, operational and research meteorological programs have grown to address and support many environmental, safety, and health issues. Due to the complexity of activities, it was recognized that efforts should be made to coordinate meteorological operations and research among the field offices to enhance cost effectiveness and productivity. To address these considerations, the DOE Meteorological Coordinating Council (DMCC) was formed in 1994, and has been providing support to DOE and NNSA meteorological programs for 10 years. The following narrative highlights meteorological activities at 15 separate DOE and NNSA sites. The activities are subdivided into operational and research components. The DMCC narrative is the last entry signi-

fying the importance of this program in alleviating meteorological and safety coordination across the DOE sites.



## ARGONNE NATIONAL LABORATORY (ANL)

### Operational

Argonne National Laboratory (ANL) is one of DOE's largest research centers. It is also the nation's first national laboratory, chartered in 1946. ANL is managed and operated by the University of Chicago (UC) for the DOE Chicago Operations Office. Argonne occupies two sites, designated as ANL-East in Illinois and ANL-West in Idaho. The Illinois site is surrounded by forest preserve on 1,500 wooded acres about 25 miles southwest of Chicago's Loop. The site also houses the DOE Chicago Operations Office. Argonne-West occupies about 900 acres about 50 miles west of Idaho Falls in the Snake River Valley. It is the home of most of the ANL major nuclear reactor research facilities.

There are three divisions, Environmental Research (ER), Decision and Information Sciences (DIS) and Environmental Assessment (EAD) at ANL with meteorological research or operational program support. Two cross-divisional groups are involved in these programs at ANL: the Atmospheric Research Section (ARS) and the Atmospheric Emergency Preparedness (AEP) Group. The ARS is composed of scientist with research activities in both basic and applied science; particular technical strengths are in the areas of air-surface exchange, remote sensing, atmospheric chemistry, and numerical modeling. About half of the ARS support is currently devoted to activities associated with the DOE Atmospheric Radiation Measurement (ARM) Program. The AEP is composed of scientists and engineers in two divisions involved in programs

with a greater emphasis on applied science. Particular technical strengths include air pollution meteorology, emergency preparedness and response, and stochastic systems simulations. More than half of the AEP support is associated with the DOE Protect Critical Infrastructure Program involving chemical and biological agents.

ARS operates and maintains a 60-meter meteorological tower and supplies meteorological data for emergency response, facility operations, and regulatory compliance for ANL operations. Wind and temperature measurements are taken at the 10-meter and 60-meter levels. Real-time and historical data are available via the Web (<http://gonzalo.er.anl.gov/ANL-MET>).

### Research

As part of a larger program for the protection of subway systems from terrorist attacks using chemical agents, AEP Group is installing sonic anemometers as well as temperature and pressure sensors in the subway tunnels of a large urban subway system. These instruments will assist in the understanding of flows in the tunnels, which are driven by a combination of:

- The "piston" action of train motion; and,
- Buoyancy effects and above-ground forcing.

Measurements from these instruments will be correlated with the above ground measurements to develop and validate predictive and emergency response models for flow and dispersion in subway systems.

The AEP group research also focuses on the analysis of routinely measured meteorological data to provide atmospheric boundary layer turbulence information for atmospheric dispersion calculations. Under the Department of the Army Chemical Stockpile Emergency Preparedness Program (CSEPP), ANL provides support to improve the collection efficiency and



quality of meteorological data measured at the Army's Demilitarization towers. The data are used the emergency operation centers in support of emergency response exercises and for use in real-time in the event an actual accident. The goal of the CSEPP support is to improve the accuracy and robustness of the data obtained from the meteorological monitoring stations and to develop unified quality control and analyses procedures of the data collected by the towers.

Key support is also provided to Department of Transportation (DOT) in applying an ANL-developed 5-year meteorological database for over 100 locations in the United States to conduct statistical analyses of hazardous materials incidents on a national basis.

Recent work for DOT has centered on development of the Table of Initial Isolation and Protective Action Distances for the 2000 Emergency Response Guidebook. Protective Action Distances are given in the Table for over 200 toxic-by-inhalation chemicals and generic compounds for both daytime and nighttime accidents, and represent the safe distance for 90% of hazardous materials transportation accidents considering variability in meteorology and spill size. Recent work for DOT has also involved conducting national risk assessments for transportation of certain high volume toxic chemicals like chlorine, ammonia, hydrogen fluoride and sulfur dioxide.

The Atmospheric Boundary Layer Experiments (ABLE) is one of several

DOE supported research programs conducted by the ARS (Figure 3-DOE-1). ABLE is located on the lower Walnut Watershed, mostly in Butler County east of the city of Wichita, KS. This location is within the existing boundaries of the DOE ARM Southern Great Plains (SGP) Clouds and Radiation Test-bed (CART) site. The establishment of this facility offers a virtual atmospheric observatory and provides essential research tools for addressing a myriad of unresolved fundamental questions in atmospheric research. The ABLE provides a continuous view of processes in the lower atmosphere over a limited domain within the SGP CART site.

The initial focus of ABLE is measurement of the planetary boundary layer (PBL) where almost all interactions between the atmosphere and humans take place. Many scientific issues may be addressed by use of such a facility, including:

- Natural disaster reduction and public safety;
- Safe and efficient aviation and other transportation;
- Agriculture;
- Water resource management;
- Effective energy production, use and environmental protection;
- Space flight operations;
- Defense; and,
- Related areas of Earth Science.

Instrumentation at the ABLE site includes winds, temperatures, moisture, surface net radiation and soil moisture as the minimum set of atmospheric observations.

The initial set of equipment, which is available at ABLE includes:

- Three 915 MHz RWP-RASS (wind speed and direction, virtual temperature profiles);
- Three minisodars (wind and turbulence profiles between heights of 10 m and 200 m);
- One lidar ceilometer (cloud base height);
- One balloon-borne sounding sys-

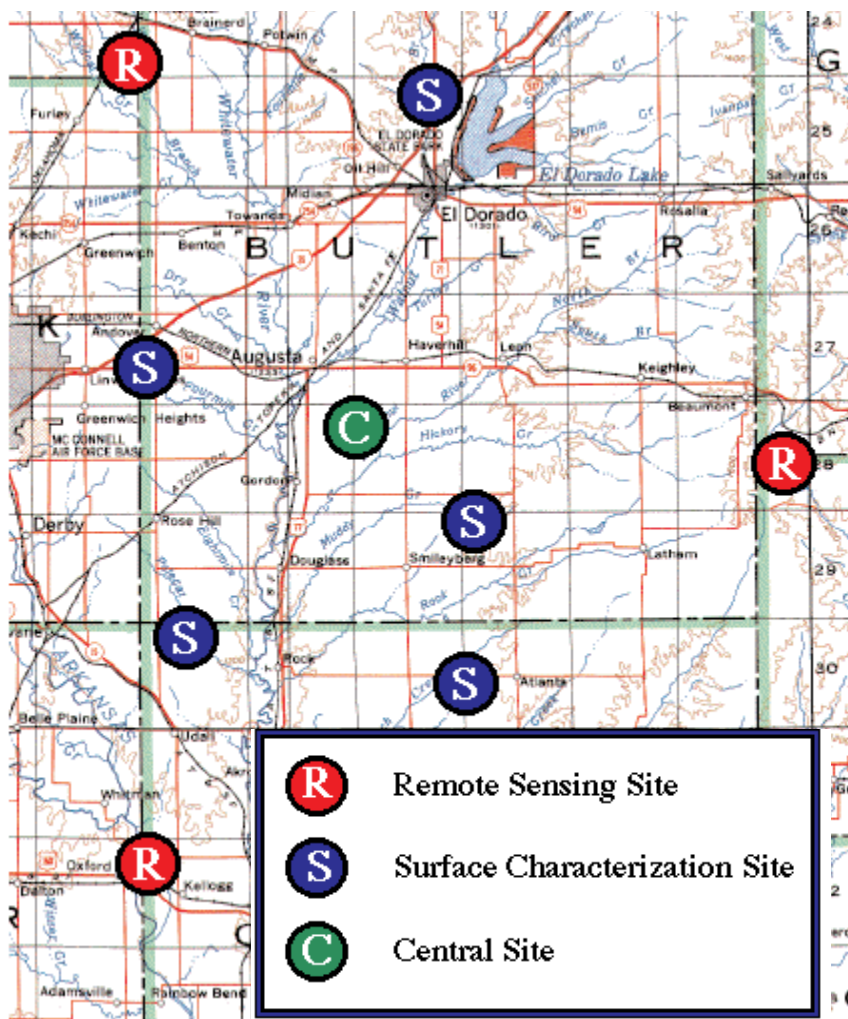


Figure 3-DOE-1. DOE Atmospheric Boundary Layer Experiment (ABLE) site locations in the Midwest.

tem (wind, temperature, moisture profiles);

- Five surface flux stations (surface sensible and latent heat, ground heat storage);
- Five soil moisture sampling stations (soil moisture, soil temperature);
- One satellite data receiver-processor;
- One data hub/central location for data collection; and,
- One (extra) instrument pad for visiting scientist instrument accommodation.



## BROOKHAVEN NATIONAL LABORATORY (BNL)

### Operational

The BNL, under the responsibility of the Brookhaven Area Office, has been active in both operational meteorology and atmospheric sciences for the past 50 years. BNL is now managed by Brookhaven Science Associates, which is a joint venture by Battelle Memorial Institute Incorporated, The Research Foundation of the State University of New York at Stony Brook, and six other core university partners. Meteorological operations and research cover a wide range of programs encompassing interpretive and theoretical studies. BNL is located near the geographical center of Long Island, New York. Long Island is glacial in origin and, as a result, has sandy soil, mostly gentle undulating contours, and a single water aquifer for the entire island. Elevations vary between 20 meters and 35 meters. The BNL site is rectangular and approximately 5,200 acres in area. Winds are predominantly southwesterly, and plume dispersion studies show that it is essential to monitor winds well beyond laboratory borders. The New York City NWS Weather Forecast Office is located at BNL. This office has an umbrella of cover-

age that includes an estimated population of one million. Nearby, in Bohemia, is the NWS Eastern Regional Headquarters that administers a 12-state region.

The mesoscale meteorological measurements necessary for emergency response are the responsibility of the Meteorological Services Group, a support group under the Department of Applied Science, Environmental Biology and Instrumentation Division (EBID).

The Meteorological Services Group maintains two meteorological towers, 10-meter and 88-meter, and an instrument shelter. By integrating redundant pairs of standard, approved meteorological sensors throughout the system, an overall data availability of better than 99 percent is achieved. The real-time data are merged into the laboratory emergency response network. A database of 50 years (in digital format since 1960), one of the longest continuous meteorological time series in the United States, is archived and is available. A real-time monitoring network with worldwide web access covers the eastern end of Long Island. Coastal weather stations at Smith Point and Orient Point transmit data each minute. Pollution-monitoring data buoys are added during field programs.

The Meteorological Services Group provides a locally tuned forecast twice daily during normal working hours. Weather forecasts and data are available by telephone or the Internet ([www.weather.bnl.gov](http://www.weather.bnl.gov)). During severe weather events updates are given every three hours and, in the case of a hazardous material or radiological release, a member of the Meteorological Services Group will assist the

emergency coordinator with regular forecasts and information on local wind fields and gustiness.

### Research

Areas of meteorological research at BNL include:

- Instrumentation development for field studies of atmospheric constituents, air-sea interaction, and laboratory experiments;
- Gaseous tracer studies of atmospheric transport and dispersion;
- Aerosol formation and behavior;
- Atmospheric pollution studies
- Modeling of atmospheric chemical reactions;
- Acid rain studies both in the field and in the laboratory;
- Theoretical and observational studies of radiation transfer and fluxes; and,
- Analysis of data and development of parameterizations relevant to global climate change.

The ARM Program provides the stimulus for a wide range of climate-related studies. The ARM ocean monitoring program is developing instrumentation and a broad ship- and buoy-based observational network in the tropical western Pacific Ocean. The Atmospheric Chemistry Program (ACP) supports the Atmospheric Chemistry Division's (ACD) concern with aerosol sources, transport, and fate in the global atmosphere and the overall, and the little understood, impact of aerosols on global climate dynamics. The ARM External Data Center is the center for collection, archival, and dissemination of all climate-related data sets for the ARM program.

An exciting new effort in radar meteorology focuses on algorithms for cloud detection and cloud mapping using both the WSR-88D radar network and research radar. BNL is a site in the National Aeronautical and Space Administration (NASA) Solar Irradiance Network and continuous short wave absorption measurements are



made here. In a related NASA study, oceanic aerosol optical depths are measured and used to validate absorption algorithms in the SeaWiFS ocean color program.

The Optical Remote Sensing (ORS) group within the Department of Advanced Technology (DAT) is presently modifying one of its Raman lidar systems for vertical profiling of carbon dioxide. The Raman lidar instrument is a self-calibrating sensor that means that data from a variety of locations in the world can be compared. With the incorporation of a large (1.25 m) antenna and advanced filters and detectors, a vertical profile of CO<sub>2</sub> concentration with a precision of 1 part per million (ppm) (Note: atmospheric mean = 370 ppm) and maximum height of two to three km can be produced routinely. These profiles will support model development and validation. Importantly, comparison of CO<sub>2</sub> concentrations collected throughout the world and over time will prove invaluable in confirming adherence to the Kyoto protocols.

## HANFORD SITE

### Operational

Beginning in 1944, meteorological services have been provided to the Hanford Site. The Hanford Site is an area of 560 square miles within the semi-arid and sparsely vegetated Columbia River basin in southeastern Washington near Richland, Washington. Since 1965, the Pacific Northwest National Laboratory (PNNL) operated for the Department of Energy (DOE) by the Battelle Memorial Institute, has managed the Hanford Site meteorological program. Not only has operational support been provided, but also supporting research into atmospheric processes has been a key part of the PNNL support to DOE. Within PNNL, the Environmental Technology Directorate provides day-to-day operational meteorological and emergency response support to the Hanford site.



Through funding from DOE, the PNNL Meteorological and Climatological Services Project (MCSP) provides meteorological monitoring and operational support to the Hanford Site. The monitoring system consists of an array of 26 10-meter towers, three 60-meter towers and one 125-meter tower instrumented with temperature and wind direction and wind speed sensors (Figure 3-DOE-2). Atmospheric pressure and precipitation data are also collected by this monitoring system. Meteorological data from this network is transmitted via UHF radio to a computer, which decodes the data and plots graphics products for immediate display and use by Hanford Meteorological Station personnel.

Meteorological services include emergency response functions, weather forecasting for onsite operations and special projects, and climatology support. MCSP support to the Hanford site includes: extensive data acquisition via a site-wide meteorological monitoring network; weather forecasting services 24-hours/day during Monday through Friday; weather forecasting services eight-hours/day on

weekends and holidays; hourly surface observations, and six-hourly synoptic observations; monthly and annual climatology data summaries; and, meteorological input to annual environmental reports.

PNNL atmospheric sciences staff operate meteorological, atmospheric transport and dispersion and dose assessment, and information display workstations at the Hanford Site's Emergency Operations Center (EOC). Atmospheric sciences staff are involved in facility planning, exercise development, and training activities for Hanford's emergency preparedness program. Assistance is also provided to state and local emergency operations facilities. PNNL staff members have developed MetView software to graphically display Hanford Site and regional meteorological data to support a variety of emergency preparedness and research applications. Staff members have also developed the Air Pollutant Graphical Environmental Monitoring System (APGEMS)-family of software products to improve the ability to rapidly and accurately estimate the atmospheric transport and dispersion and human health and environ-

mental consequences of accidental or unexpected releases on or near the Hanford Site. The flexible user interface and graphical output capabilities of APGEMS allow it to efficiently support a range of users including first responders, experienced hazard assessors, and decision makers.

#### Research

The Fundamental Sciences Directorate conducts research into meteorological, climatological, and atmospheric chemical processes in support of other major DOE programs such as the Atmospheric Radiation Measurements (ARM) program and the Atmospheric Science Program (ASP).



Figure 3-DOE-2. Meteorological towers record temperature and wind direction and speed at various levels.

PNNL plays both management and developmental roles in the ARM program which is focused on the development of cloud and radiation databases and data products that are critical to improved understanding of global and regional climate change and the improvement of climate research and prediction models. In addition to its roles in ARM, PNNL also conducts research into the processes affecting radiation transfer through the atmos-

phere and the effects of greenhouse gases, aerosols, and clouds on regional and global climate. The PNNL Atmospheric Remote Sensing Laboratory is a portable system for studying the vertical structure of atmospheric constituents, particularly clouds, which govern radiation transfer through the atmosphere. Capabilities of the Environmental and Molecular Sciences Laboratory (EMSL) are used to conduct molecular level research into aerosol formulation and aging. Carbon dioxide emissions research is aimed at providing a scientific basis for forecasting future emissions of carbon dioxide and other gases of radiative importance.

In support of the ASP, PNNL uses ground-based and airborne measurements systems, numerical and conceptual modeling, and data analysis to conduct research into the vertical transport and mixing processes that govern the distribution in the lower troposphere of trace gases and aerosols released during energy production or use and on chemical processes that govern the transformation and fate of gaseous and particulate pollutants. PNNL manages the DOE Research Aircraft Facility, a Gulfstream 159 twin turboprop aircraft that supports research in atmospheric chemistry, radiation transfer, and aerosol characteristics for DOE.

A hierarchy of atmospheric dispersion models is being developed within DOE's Chemical Biological National Security Program (CBNP) covering transport distances ranging from around individual buildings, through the urban area and beyond the urban area into the surrounding region. These models will allow individuals in intelligence, law enforcement and emergency management to adequately plan against, train for and respond to potential terrorist attacks. PNNL scientists, in collaboration with other government and private scientists, are conducting atmospheric tracer and

meteorological field studies for evaluating the models being developed within CBNP. The field studies will provide valuable information to all investigating urban dispersion, urban air quality and atmospheric transport and dispersion in general.



#### IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY (INEEL)

##### Operational

INEEL is managed by the Idaho Operations Office and is on 890 square miles of rolling, arid terrain in southeastern Idaho at the foot of the Lost River and Lemhi mountain ranges. The primary mission of the INEEL for years has been nuclear reactor research with a focus on cleanup and environmental restoration. Meteorological services and supporting research are provided to INEEL via NOAA ARL Field Research Division (FRD). The Division, under administration from various agencies, has provided support to INEEL for over 50 years. Its current mission to DOE/ID is to support emergency response and operations with real-time meteorological data, climatology data, weather predictions, dispersion calculations, and consultation. ARL FRD maintains other capabilities that are not funded directly by DOE. ARL FRD designs, arranges, and conducts field studies as needed to evaluate the performance of transport and dispersion models over local, regional, and continental scales, and to obtain high quality databases for model improvement. An airborne geosciences program is also maintained to measure fluxes of carbon dioxide, water vapor, and other atmospheric constituents that affect climate. These



interactions provide ARL FRD staff with additional insights that aid in the understanding of local meteorological phenomena.

ARL FRD operates a large meteorological monitoring network to characterize the meteorology and climatology of the INEEL site. The network consists of 33 meteorological towers that are deployed both onsite and offsite. The overall meteorological measurement program is designed to provide representative data for the INEEL to meet specific operational and potential emergency response situations. The network covers an area of approximately 15,000 square miles. Many of the towers are 15-meters tall and provide wind speed and direction at 15-meters and air temperature at 2-meters and 15-meters. Instrumentation on 15 of the 15-meter towers also measure relative humidity at 2-meters, precipitation, and global solar radiation. Barometric pressure is provided on 11 of the towers. The other three towers range from 46-meters to 76-meters in height and are instrumented at multiple levels. The sensors at all stations are scanned every second and averaged or totaled over five minutes.

The data are subsequently retrieved into the data display and archive system at the ARL/FRD office through a radio repeater located at an elevation of 8,930 ft MSL. Continuous wind and temperature profiles are obtained from a 915 MHz radar wind profiler and RASS. A Doppler SODAR supplements the wind profile at lower levels with higher resolution data. Meteorological data are quality-controlled through automated and manual processes.

INEEL meteorological monitoring and emergency response efforts are enhanced with the use of an ARL FRD meteorological data display and visualization program known as INEELViz. This program has been widely deployed at 50 sites on and around the INEEL for access by federal, state, and

Indian tribes via the Internet.

Within INEELViz, meteorological data are displayed in real-time and overlaid on maps of the local area that include political and terrain features. In addition, the local MDIFF puff dispersion model can be accessed through the INEELViz front-end and the model output can be displayed as trajectories or concentration isopleths on the INEELViz display screen. The incorporation of RSAC dose conversions permits the user to also view real-time dose estimates from the model output. These features have become very useful enhancements to the INEEL emergency response capability.

#### Research

Partnerships forged with DOE/ID, the State of Idaho INEEL Oversight Program, and the Shoshone-Bannock Indian Tribes have resulted in additional methods of meteorological data dissemination. Meteorological and background nuclear radiation data from four public access sites on and surrounding the INEEL are displayed at nearby kiosks in real-time. Additional information on nuclear radiation and meteorological tutorials are presented at the kiosks. The data are also available on the Internet at <http://over-site.inel.gov>. ARL FRD maintains its own web site at [www.noaa.inel.gov](http://www.noaa.inel.gov).



#### LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL) Operational

LLNL is located in a valley in California's Coast Range Mountains about 25 miles east of Oakland. LLNL covers approximately 2 square miles and is operated by the University of California for the DOE Oakland Operations Office. Two groups are involved in the atmospheric sciences at LLNL:

1. Environmental Protection Depart-

ment (EPD); and,

2. Atmospheric Sciences Division (ASD).

EPD operates a 40m tower and supplies meteorological data for facility operations, regulatory compliance, and emergency response. Real-time and historical data are available at <http://www-metdat.llnl.gov/>.

The National Atmospheric Release Advisory Center (NARAC) is a centralized emergency response resource supporting federal agencies (<http://narac.llnl.gov/>). The mission of NARAC is to deliver realistic real-time graphical dose and exposure assessments to emergency decision-makers to assist in the protection of populations at risk for releases of radiological and other hazardous material to the atmosphere (Figure 3-DOE-3). NARAC has developed specific tools to assist elements of the DOE Consequence Management assets, including the Nuclear Emergency Search Team (NEST), Accident Response Group (ARG), Federal Radiological Monitoring and Assessment Center (FRMAC) (<http://www.nv.doe.gov/programs/frmac/default.htm>), and the Radiological Assistance Program (RAP). Under DOE direction, NARAC supports National Special Security Events, such as the winter 2002 Olympics. NARAC

also supports DOE sites and Emergency Operations Centers around the US (<http://www.nnsa.doe.gov/>).

NARAC's central emergency response system consists of automated continuous worldwide meteorological data acquisition, detailed worldwide terrain and geographic mapping databases, a suite of atmospheric dispersion models and source models to assess explosions, fires, spills, or other types of radiological, chemical, biolog-



ical releases. The system includes a high-resolution, terrain-following, variable-gridded diagnostic meteorological model (ADAPT) and a prognostic model with parameterizations for urban settings (COAMPS) coupled with a generalized Lagrangian particle dispersion model (LODI).

A staff of NARAC emergency response model experts provides a 24-hour response service. To minimize response time, NARAC has developed and supplied over 40 federal facilities around the US with software that performs meteorological data acquisition, local-scale stand-alone modeling, and reaches back to LLNL for detailed simulations. NARAC mapped products are delivered in 5-10 minutes for a computer-linked site and up to 60 minutes for a non-computer-linked site. Supported sites and organizations can use the client-server-based NARAC iClient tool (for heavy modelers) or NARAC Web (for light modelers) tools to run models and seamlessly distribute products to multiple organizations over the world wide web.

The Regional Modeling and Dispersion Group is investigates regional scale processes affecting dispersion. This group works with the Urban Group to with the goal of developing a seamless set of validated diagnostic and prognostic tools from the building to urban to regional scales. In collaboration with LANL, LLNL developed a prototype prediction capability to assist in multi-agency smoke and fire management of wildfires.

#### Research

Scientists in the Atmospheric Science Division (ASD) (<http://asd.llnl.gov/>) at LLNL perform pioneering research on global climate and chemistry and predict the local, urban, regional, and global transport and fate of hazardous and toxic pollutants. Research is focused on major national energy and security policy issues and is based primarily on development and use of advanced computa-

tional simulations of the atmosphere, oceans, and biosphere.

ASD conducts research in four areas:

- Atmospheric hazards and consequence assessment;
- Atmospheric transport & fate;
- Carbon cycle and climate model physics; and,
- Climate change & model evaluation.

ASD Major Programs Include:

- Program for Climate Model Diagnosis & Intercomparison (PCMDI);
- Institute for Research on Climate Change & Its Societal Impacts (IRCCSI); and,
- NARAC Programs and the National Atmospheric Release Advisory Center (NARAC).

PCMDI's mission is to develop improved methods and tools for the diagnosis, validation, and intercomparison of global climate models, and to conduct research on a variety of problems in climate modeling and analysis (<http://www-pcmdi.llnl.gov/>).

The mission of IRCCSI is to improve understanding of climate change and its societal impacts, by facilitating collaborations between the University of California-operated DOE laboratories

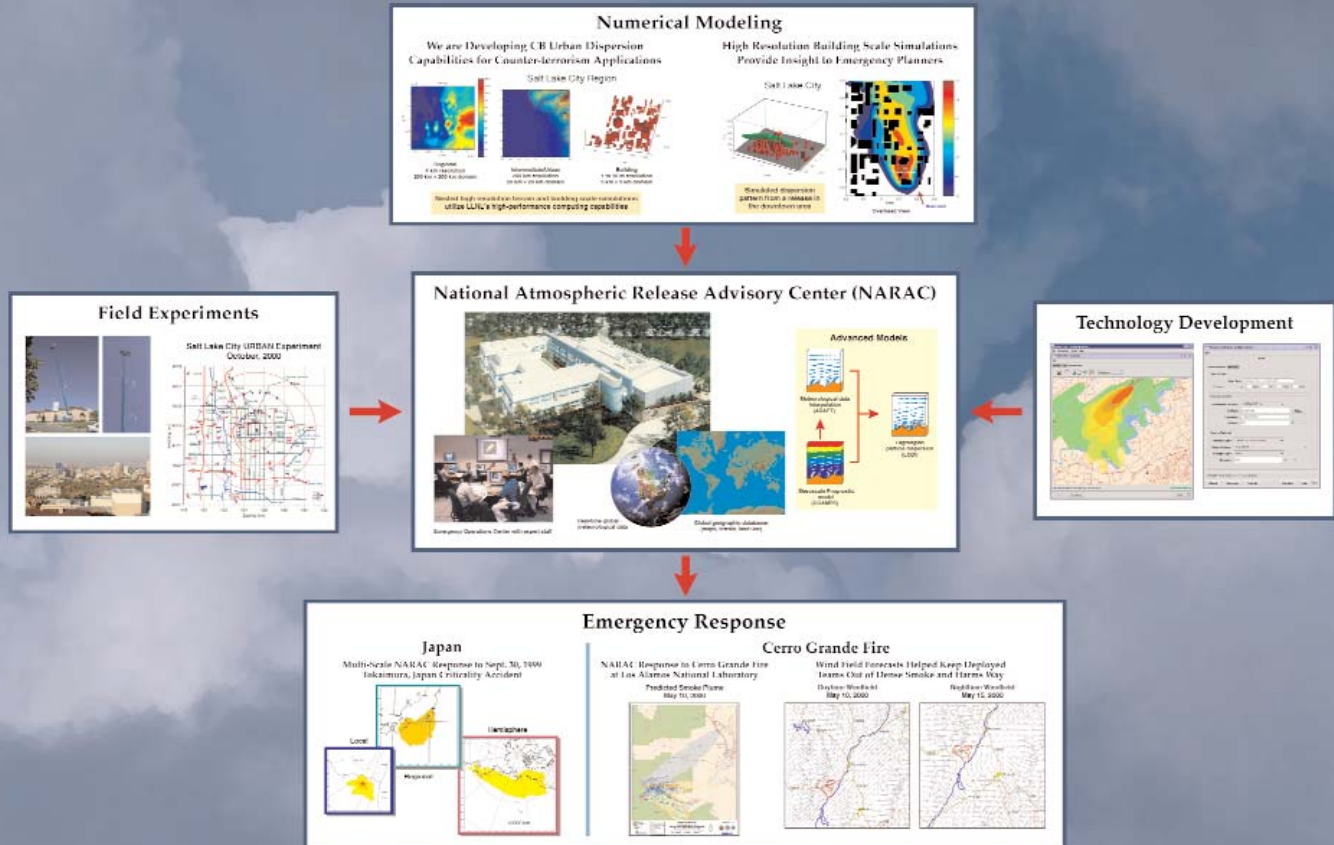
(i.e., LANL, LLNL, and LBNL) and University of California campuses (<http://irccsi.llnl.gov/>). In particular, DOE wishes to link the Laboratories' capabilities in high-end climate modeling and climate science with the expertise in regional climate and societal impacts issues resident at the University of California campuses.

The urban Research & Development effort is developing a coupled suite of multi-scale dispersion models to effectively respond to urban releases. LLNL was a co-leader of the Joint Urban 2003 (i.e., JU2003) field study in Oklahoma City, OK, the largest most complex urban tracer experiment performed to date. The Pacific Northwest National Laboratory (PNNL) was the overall leader, while LLNL, LANL, LBNL were co-Principal Investigators. JU2003 was supported by the Department of Homeland Security (DHS), the Defense Threat Reduction Agency (DTRA) and the Department of Defense (DoD). Data from this study is being used to identify key urban physics and to evaluate NARAC's suite of urban models. A new three-year project has begun to develop a next-generation building-



Figure 3-DOE-3. Each of DOE's eight Regional Coordinating Offices maintain a 24-hour response capability for radiological emergencies that may occur in states served by its region.

## An Integrated Suite of Research, Development, and Operational Programs



## To Predict and Assess the Dispersal of Hazardous Material

scale computational fluid dynamics model.

Examples of on-going operational integration projects include:

- Integration of mapping systems for field measurement, modeling results, and dose assessment to support DOE Nuclear Incident Response Team (NIRT) capabilities (SNL, RSL) - DOE;
- Enhancement of source term models for radiological, prompt (i.e., blast, thermal, radiation, explosive effects), and chemical-biological releases (SNL) - DOE and DHS;
- Improved dose-response and toxic load models (Edgewood Chemical and Biological Center, U.S. Army) - DHS;
- Development of building infiltration models to predict indoor exposures (with LBNL) - DHS;
- Incorporation of an empirical urban model (Defense Science and Technology Laboratory, UK) - DHS;

- Meteorological and outdoor dispersion modeling for an operational subway system - DHS; and,

- Standardization and integration with the EPA/NOAA CAMEO/ALOHA toxic chemical databases and atmospheric dispersion models - DHS.



LOS ALAMOS NATIONAL LABORATORY (LANL)

### Operational

LANL is operated by the University of California (UC) under the responsibility of the DOE Albuquerque Operations Office (ALOO), and is spread across 43 square miles of the Pajarito Plateau at the foot of the Jemez Mountains that extend up to around 900

meters above the plateau. LANL is about 30 miles northwest of Santa Fe in north central New Mexico. The Pajarito Plateau slopes to the east-southeast, dropping 400 meters across the Laboratory, with canyons and mesas running along the slope of the plateau. The broad Rio Grande Valley lies to the east of the laboratory. Los Alamos has a semi-arid, temperate, mountain climate.

The operational meteorological program at Los Alamos operates a network of six towers (ranging in height from 23 meters to 92 meters), a monostatic Doppler SODAR, and three supplemental precipitation stations. Data from four instrumented meteorological towers that are located on the Pajarito plateau drives a diagnostic wind field for the program's plume modeling capability. A fifth tower is located in Los Alamos Canyon to give information on the larger canyons in the area,

and a sixth tower is located on top of Pajarito Mountain to measure ambient conditions. The SODAR gives information on winds up to the level of the Pajarito Mountain tower.

More than 100 instruments, consisting of over 20 different types of sensors, are used to collect data throughout the network. Variables measured by the program can be grouped into the categories of wind, SODAR-derived wind, atmospheric state, precipitation-related, radiative fluxes, eddy heat fluxes, subsurface measurements, and fuel moisture. Data collected by the network are checked for quality before its archiving, and raw data and real-time displays of graphs and tables are made available via the Internet.

The LANL Air Quality Group (AQG) provides regulatory and environmental surveillance leadership and services to meet LANL air quality obligations and public assurance needs. The group develops and implements programs to ensure and address institutional compliance with State and Federal laws related to air quality regulations, DOE orders for emergency management, air quality surveillance, dose assessment activities, and community concerns related to air quality issues. The group takes a proactive approach to managing air emissions by providing continuous air monitoring and measurement of external penetrating radiation onsite and offsite.

The group also coordinates LANL activities to ensure full compliance with air emission regulations, providing monitoring and modeling for emergency response, and assisting operating groups in developing and implementing new methods and systems to reduce emissions to as low as reasonably achievable. The monitoring capabilities of the AQG are supplemented by the Atmospheric and Climate Sciences Group (ACSG) field team, which operates various sensor systems including a unique Raman lidar system to obtain images of atmospheric water

vapor distributions.

#### Research

Research within the LANL Atmospheric and Climate Sciences Group supports DOE missions in both the defense and civilian sectors, such as work in the propagation of very-low-frequency sound (i.e., infra-sound) waves. Modeling studies contributed to understanding of propagation and, in particular, sources of "infra-sound". Just as it is possible to infer earthquake epicenters from seismic wave observations, "infra-sound" sources can be inferred from atmospheric observations. This work is an important component of monitoring compliance with the proposed Comprehensive Test Ban Treaty (CTBT). The CTBT work involves a number of organizations within DOE and DOD community, including interactions with other DOE laboratories within the CTBT Research and Development program.

Operational issues involve close work with the Air Force Technical Applications Center (AFTAC) at Patrick AFB, Florida, the DOD organization that handles monitoring systems. In addition, several active international collaborations with other infrasound researchers are ongoing.

The Meteorology Team within the ACSG at LANL conducts analysis and modeling on microscale to mesoscale atmospheric flows and phenomena. In support of the DOE CBNP, a model for High Resolution and Strong Gradient (HIGRAD) applications is being used to study the effects of radiative heating and shading around groups of buildings. The objective of this study is to determine how these processes may influence the transport of agents within the urban environment. On larger scales, the team is examining the influence of flow merger and urban roughness on the vertical transport and mixing of pollutants with the Regional Atmospheric Modeling System (RAMS) for several western U.S. valleys and basins. This project is in sup-

port of the DOE Environmental Meteorology Program (EMP) and for the EPA. As part of the LANL initiative in Coupled Environmental Modeling, researchers within the Meteorology Team are developing a physics-based fire behavior model, FIRETEC, and coupling this model to the HIGRAD atmospheric dynamics code to examine the details of the interaction between local winds and the intense heat generated by wildfires. Also as part of this initiative, a land surface model is being coupled that includes hydrologic processes (i.e., SPLASH) to the RAMS mesoscale model for multi-seasonal simulations of the water resources of the upper Rio Grande Basin.

Meteorology team members are also working on the LANL Urban Security project, which is linking physical and urban growth models to address the needs of cities. In this framework, we are using the RAMS model to provide meteorological fields for use by air chemistry, urban runoff, and other models. The Meteorology team within the ACSG conducts analysis and modeling on microscale to mesoscale.

On global scales, research within the LANL meteorological community involves the study of climate change and variability. A major project is the development of a global coupled ocean-atmosphere model sponsored by the DOE Climate Change Prediction Program. The global model being developed consists of a Los Alamos global ocean Global Climate Models (GCMs) Parallel Ocean Program (POP), the Los Alamos sea-ice model (CICE), the National Center for Atmospheric Research (NCAR) Community Climate Model (CCM3), and a "flux coupler" to link the media consistently. The two GCM's and the CICE model exchange heat, momentum, and water mass across the air-sea boundary. A ten-year synchronized simulation revealed the synoptic weather events, seasonal cycles and inter-



annual variations.

Observations related to understanding global climate are the focus of the Tropical Western Pacific (TWP) Program Office LANL, an element of the DOE ARM Program. The TWP Program Office is responsible for the development and operation of the TWP CART locale, a large expanse of tropical-ocean and maritime-continent lying roughly between 10 degrees S and 10 degrees N latitude and from 135 degrees E to 150 degrees W longitude. The maritime continent area is largely in the southwest and the open ocean area in the northeast of the locale. The local climate is characterized by warm sea surface temperatures, deep and frequent atmospheric convection, high rain rates, strong coupling between the atmosphere and ocean, and substantial variability associated with El Niño Southern Oscillation (ENSO) phenomenon.

Scientific questions that need to be addressed in the TWP can be grouped under three main headings:

1. Radiation budget and cloud forcing;
2. Water and energy budgets; and,
3. Ocean-atmosphere interactions.

The program supports a variety of operations at LANL. The primary client of the program is the Emergency Management Group, for which the program provides a plume modeling capability. Other clients use the program's data for such activities as operations and planning, hazard and accident analyses, environmental studies, support for experiments, compliance, and documentation.

(NNSA/NSO). The NTS has been the Nations' underground nuclear weapons testing facility and is now used to support sub-critical experiments and other national defense missions of the United States. The NTS occupies 1,350 square miles of south central NV and is approximately 75 miles northwest of Las Vegas, NV. The topography of the NTS is complex with a system of dry lakebeds and mountains. Elevations range from nearly 2,700 feet (ft) above mean sea level (MSL) to 7,600 ft MSL. The climate is arid.

Meteorological services are provided to NNSA/NSO by components of NOAA. NOAA has had a presence on the NTS for more than 45 years through the implementation of Interagency Agreements (IA). During this time, NOAA personnel have built a solid technical reputation in meteorological operations and emergency response. Presently, NOAA support is provided by Air Resources Laboratory Special Operations and Research Division (ARL/SORD) recognized for its expertise in the transport, dispersion, and deposition of radioactive and toxic materials (Figure 3-DOE-4). ARL/SORD has developed a rapid emergency response capability for the unlikely occurrence of an accidental release of radioactive or hazardous material into the atmosphere.

ARL/SORD provides full meteorological support to all NNSA/NSO operations on and off the NTS. Meteorology plays a key role in environmental, safety, and health responsibilities of NNSA/NSO. The ARL/SORD staff is responsible for conducting a

and response activities of NNSA/NSO. ARL/SORD supports a comprehensive meteorological program on the NTS, and provides meteorological and climatology services required in supporting the NNSA/NSO and contractor programs at the NTS, and elsewhere, as necessary.

Personnel at ARL/SORD also consult with senior scientists and engineers at the DOE National Laboratories, NASA, private contractors, Desert Research Institute (DRI), United States Geological Service (USGS), United States Forest Service (USFS), and other NOAA laboratories.

ARL/SORD operates and maintains a large meteorological monitoring network (MEDA) to characterize the meteorology and climatology of the NTS. This network consists of 29 10-meter towers and two, 30-meter towers. Wind direction and speed is measured at the 10-meter level on all the towers and temperature and relative humidity is sampled at the 2-meter level. Data from these towers are transmitted via microwave radio to a central processor that checks the data, creates data files, and archives the data every 15 minutes. The data files are accessed by microcomputer to create graphics products for operational use and for immediate display at 15-minute intervals. The MEDA system was upgraded in 2004 to include sonic anemometers.

SORD also operates two, 915MHz vertical profilers on the NTS. One tower is located in the middle of Yucca Flat and the other tower is located at the Hazardous Materials Spill Center (HMSC) in Frenchman Flat near Mercury, NV. In addition, a NOAA full surface radiation (SURFRAD) budget station is operated and maintained at the Desert Rock Meteorological Observatory (DRA) located in the southern part of the NTS. Upper-air soundings are taken twice daily, at 00 and 12 Universal Time Coordinated (UTC) from the DRA facility.



#### NEVADA TEST SITE (NTS) Operational

The NTS is managed and operated by the National Nuclear Security Administration/Nevada Site Office

modern program in support of nuclear and non-nuclear projects authorized by NNSA/NSO. Furthermore, the mission of ARL/SORD involves technical support to the emergency preparedness

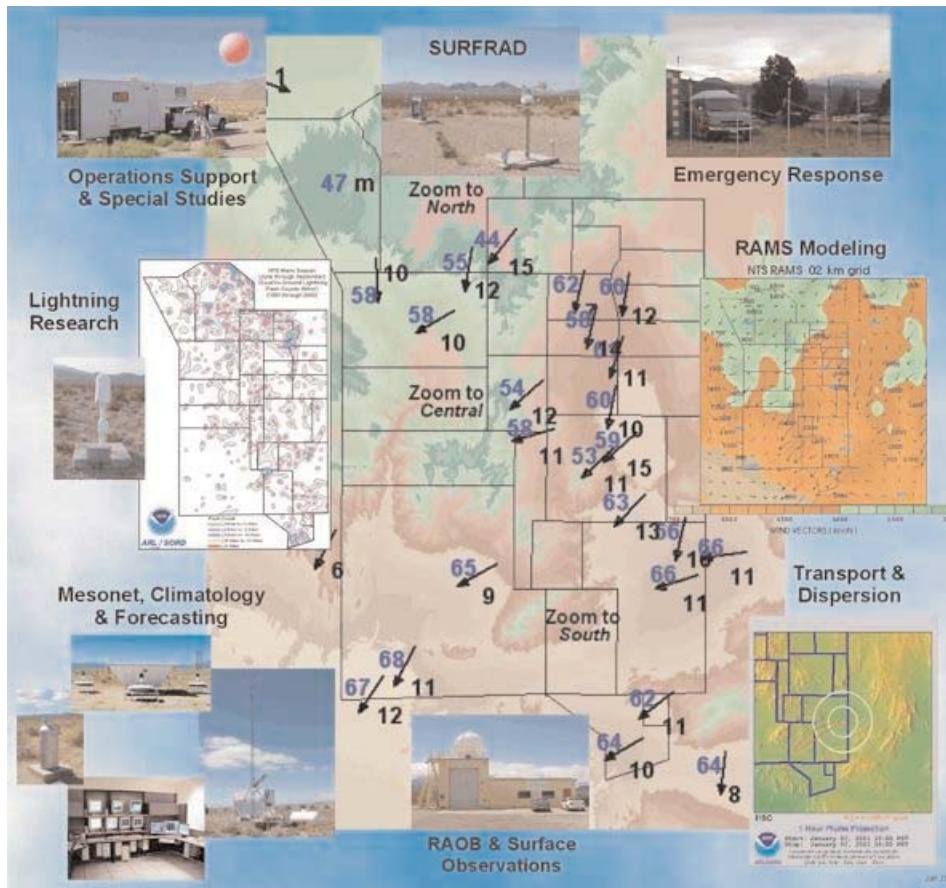


Figure 3-DOE-4. Air Resources Laboratory (ARL)/Special Operations and Research Division (SORD) conducts basic and applied research on problems of mutual interest to National Oceanic and Atmospheric Administration (NOAA) and Department of Energy (DOE), that relate to the Nevada Test Site (NTS), its atmospheric environment, and its emergency preparedness and emergency response activities.

ARL/SORD also operates mobile upper-air sounding systems and mobile pilot balloon (PIBAL) equipment to support special projects requiring winds aloft data in real-time.

Large-scale meteorological data and National Center for Environmental Predictions (NCEP) weather forecast products are received via AWIPS, or from the University Center for Atmospheric Research (UCAR) and ARL-Silver Spring, MD. Weather products supplied to DOE contractors, the National Laboratories (e.g., SNL, LANL, and LLNL), the NWS, and Nellis AFB, include real-time cloud-to-ground lightning flash graphical products and local forecast products. Furthermore, a three-tiered lightning alert and warning procedure has been implemented as part of the NTS Inte-

grated Safety Management program.

ARL/SORD has also implemented the RAMS model for the NTS and Southern Nevada. This model predicts boundary layer airflow and precipitation over complex terrain. The RAMS code accesses the NCEP predictive model outputs and is run twice daily at the University of Nevada at Las Vegas (UNLV) Supercomputer Center on a daily basis. In addition, the NOAA HYSPLIT/HARM dispersion model has been installed on microprocessors in the SORD Meteorological Assessment Center.

ARL/SORD provides meteorological monitoring support and project-specific weather forecast services to NEST, FRMAC and ARG activities. Monitoring support includes surface and upper-air data collection and

analysis. Weather forecast service entails maintaining a constant weather watch for conditions that might impact NEST, FRMAC, or ARG operations and personnel, issuing site-specific mesoscale wind, stability, and weather forecasts, aviation weather support, and providing consultation to the On-Scene Commander (OSC) and to National Laboratories personnel. ARL/SORD maintains a web site ([www.sord.nv.doe.gov](http://www.sord.nv.doe.gov)) that includes graphical products that display current meteorological conditions on and around the NTS, including data from ARL/SORD vertical profilers, climatology data, cloud-to-ground lightning information and time-relevant plume transport and dispersion calculations.

### Research

Both basic and applied research is carried out on problems of mutual interest to DOE and to NOAA. Emphasis is on the maintenance of meteorological support to national defense projects and to the stewardship of nuclear weapons. These capabilities focus on those facets of meteorology having a direct bearing on the transport, dispersion, deposition (i.e., fall-out), and resuspension of radioactive and/or toxic materials. Other research includes documentation and study of extreme precipitation events, desert thunderstorms, cloud-to-ground lightning, and environmental issues related to air quality and visibility. In addition, the SORD program serves as a test bed for advanced NOAA meso-scale prediction models.

A NOAA Climate Reference Station was installed at the Desert Rock Meteorological Observatory in April 2004.

### OAK RIDGE RESERVATION (ORR) Operational

The ORR is home to four DOE/NSA sites: Oak Ridge National Laboratory (ORNL), the Y-12 National Security Complex, the East Tennessee Technology Park (ETTP, formerly K-25 Site), and the Oak Ridge Institute





for Science and Education (ORISE). Managed by the Oak Ridge Operations Office (OROO), the ORR encompasses nearly 100 square miles of hilly and heavily vegetated terrain in eastern Tennessee.

Formerly known as the Oak Ridge Y-12 Plant, and constructed in the early 1940's as part of the Manhattan Project to manufacture nuclear weapons components, the Y-12 National Security Complex (NSC) has now assumed a national security role under NNSA. Y-12 is an 811-acre facility located within the city limits of Oak Ridge, TN, 10 miles from the ORNL and 12 miles from the ETTP, once known as the Oak Ridge Gaseous Diffusion Plant.

Currently operated by BWXT Y-12, the national security programs at Y-12 include manufacturing and reworking nuclear weapon components, dismantling nuclear weapon components returned from the national arsenal, serving as the nation's safe, secure storehouse of special nuclear materials, providing the U.S. Navy with safe, militarily effective nuclear propulsion systems, and reducing the global threat from terrorism and weapons of mass destruction. In early 2004, the Y-12 NSC received, stored and secured a shipment of Libyan nuclear materials.

Meteorological network systems, which support day-to-day operations, are managed and operated at the three main sites by the University of Tennessee (UT)/Battelle, BWXT Y-12 and Bechtel Jacobs Company. These network systems provide data that support environmental management (permitting, facility siting and environmental impact assessment), facility safety (safety analyses), emergency management (hazards and consequence assessment), operations (work planning) and substantial research.

The BWXT Y-12 meteorological

program is operations-, environment- and safety- oriented. Y-12 is located in the narrow Bear Creek Valley, and it is bordered by two SW to NE oriented ridges, mostly covered with mature pines and hardwoods. Two meteorological towers have long formed the basis for the meteorological program - a 100-meter tower, instrumented at 10-, 30- and 100-meters, located on the valley floor at the East end of Y-12, and a 60-meter tower, instrumented at 10-, and 60-meters, located on a ridge-line at the West end. In 2003, the data acquisition system was upgraded to an Environmental Systems Corporation (ESC) Windows-based software package, accessing via Ethernet the ESC 8832 data loggers at the towers. This data acquisition package is widely used in air pollution monitoring and in other environmental compliance applications.

Given the complex terrain setting of the Y-12 NSC, a REMTECH PA-2 sodar is used to characterize the winds from 50-meters, extending above the surrounding ridges to a height of 500-meters. Redundant Windows XP polling computers collect 1-hour average sodar data, plus 1-hour, 15-minute, and 1-minute tower data. Displays of the 15-minute data are available in the operations center, in the emergency centers (including the State EOC), and on an internal web page for general use. For real-time emergency response modeling purposes, 15-minute data is also routed to the NARAC meteorological database, and to a specially-formatted file on the Y-12 EOC modeling computers. There, it is accessible by the local chemical model, CHARM®, a commercially available 3-D grid model with an extensive chemical database and source term modeling features. For most other modeling needs, the NARAC iClient model is used at Y-12, where the ridge-valley

and generally complex terrain setting has represented a prototype test and demonstration site for 3-D wind field and terrain models.

There is no on-site weather forecasting service at Y-12, but since it is in the city limits of Oak Ridge, representative forecasts are readily available from the local media, the national network services, and the Internet. Local severe weather advisories and warnings are issued by the nearby NWS Office at Morristown, TN, and they are received and disseminated by the Plant Shift Superintendent's (PSS) Office at Y-12. Also available to the PSS is a subscription weather and doppler radar service, as well as lightning detection and prediction equipment. The Y-12 Meteorologist and a Systems (Hardware/Software) Engineer maintain the program, train and assists others, as needed.

The meteorological data acquisition program at ETTP has two main towers. K-1209 is 60 meters high while K-1208 is 30 meters in height. In addition, two 10-meter supplemental towers are still operating. Lastly, a NEXRAD radar system, and The Weather Channel (TWC) are available to each of the control rooms and emergency response facilities.

The data acquisition program at the ORNL consists of three (two 30-meter and one 100-meter) meteorological towers. Meteorological data is fed to an ORNL central computer system for analysis and dissemination.

#### Research

NOAA Air Resources Laboratory/Atmospheric Turbulence and Diffusion Division (ARL/ATDD) is located in Oak Ridge near the ORR. The primary mission of ATDD is atmospheric research. Substantial research programs at ATDD are undertaken with the assistance of staff from ORISE/Oak Ridge Associated Universities (ORAU) and scientists from other national laboratories and organizations in the United States and



abroad. ARL/ATDD also works closely with the ORAU to enhance educational opportunities in atmospheric science.

ARL/ATDD research attention is focused on the physics of the lower atmosphere, with special emphasis on the processes contributing to atmospheric transport, dispersion, and air-surface exchange, and on the development and improvement of predictive capabilities using the results of this research. Many other projects are underway such as surface energy balance and CO<sub>2</sub> exchange studies and long-term studies of CO<sub>2</sub> exchange aimed at process-level understanding.

Operationally, ARL/ATDD personnel provide meteorological consultation and supplemental data for air quality analyses, environmental reports, and hazard assessments and consequence assessments. Local climatology data are routinely collected and distributed. Under NOAA funding, ARL/ATDD operates a regional network of 15 towers ranging from the Cumberland Mountains (middle Tennessee) to the Smoky Mountains on Tennessee's eastern border. Wind, temperature, and precipitation data are recovered every 15 minutes by telemetry and made available to users.

ARL/ATDD incorporates NWS forecast products into the high-resolution, regional, meteorological model (i.e., RAMS) to produce twice daily 12-hour, 24-hour, and 36-hour predictions of surface winds for eastern Tennessee, and transport trajectory predictions for the ORR.

## PANTEX PLANT

### Operations

The Pantex Plant covers 15,977 acres and is located 17 miles northeast of Amarillo, TX, in Carson County. The Plant was a World War II munitions factory and was converted to a nuclear weapons assembly facility in 1951. Today, it is the nation's only assembly/disassembly facility supporting the

nuclear weapons arsenal. Pantex Plant is a government-owned, contractor-operated facility. DOE oversees operation of Pantex Plant through the Amarillo Area Office (AAO), which reports to the Albuquerque Operations Office. Mason and Hanger Corporation had been the operating contractor since 1956. On February 1, 2001, BWXT Pantex has assumed the Pantex contract.

The Plant is composed of several functional areas, commonly referred to as numbered zones. These include a weapons assembly/disassembly area, a weapons staging area, an area for development of experimental explosives, a drinking water treatment facility, a sanitary wastewater treatment facility, and vehicle maintenance and administrative areas. Other functional areas include a utility area for steam and compressed air, an explosive test-firing facility, a burning ground for thermally treating explosive materials, and landfills. Overall, there are more than 700 buildings at the Pantex Plant.

The Environmental Protection/Restoration Department (EP/RD) of the Environment, Safety and Health Directorate is tasked with the quality assurance program for the meteorological data captured by the one on-site two-level tower located in the northeast corner of the Plant site. The data from this tower (i.e., 10-meters and 60-meters) are collected and used by the DOE NARAC site workstation, located in the Plant EOC. These data are collected and archived as 15-minute averages plus maximum and minimum values for each 15-minute period. They are primarily

used for input to the NARAC emergency response models that could be used for off-normal events involving radionuclides. Annual dispersion model calculations of offsite radiation doses from on site sources, required by 40 CFR 61, Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAP), are accomplished by the EP/RD. EP/RD uses the EPA-approved CAP88-PC atmospheric transport and dispersion model and the Pantex meteorological tower data processed into the STAR format. This department also maintains the Pantex Plant climatology database.

Meteorological tower data is also used by the Risk Management Department for plume dispersion modeling applied to the Plutonium Dispersal Consequence Analysis for the Basis for Interim Operations (BIO) validation and upgrade reports, other operations directives, and other safety analyses.

Routine preventive maintenance on the meteorological instruments as well as calibration and certification are done semi-annually by the United States Bureau of Land Management (BLM). The BLM maintenance depot at Boise, Idaho performs similar work for the United States Forest Service's own meteorological towers instruments. This work is done under a contract administered by the Pantex Emergency Management Department. The BLM Idaho depot also handles emergency repairs and replacement of sensors. Temperature and wind sensors are replaced semi-annually with calibrated and certified sensors. The barometer is replaced annually. During the semi-annual preventive maintenance



**Pantex Plant**

nance visits all of the other meteorological instruments are replaced by the BLM technician with rebuilt/refurbished, calibrated equipment, from the Idaho depot. The maintenance check also includes the telephone line, modem, and backup power supply.

As a result of a FY 2000 project meteorological tower data is now displayed on the Pantex Plant Intranet for use by Plant personnel. During FY 2001, the potential for replacing the existing wind sensor on the meteorological tower with a three-dimensional wind sensor was evaluated. In addition, replacing/upgrading the NARAC computer and software located at the base of the tower that feeds data into the NARAC Site System in the EOC was also considered.

#### Research

There are no current or projected supporting meteorological research activities planned at the Pantex Plant.



### ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE (RFETS)

#### Operational

The RFETS is managed by the Rocky Flats Operations Office (RFOO) and is located approximately 16 miles northwest of downtown Denver, CO. One of the smaller DOE sites, the facility occupies a 10 square mile area along the foothills of the Rocky Mountain Front Range.

A 61-meter meteorological tower at the west-end of the site continuously monitors meteorological conditions at surface, 10-meters, 25-meters, and 60-meters above ground level. The data are analyzed, quality assured, and assembled into data sets for use in atmospheric modeling, climatology, and other analyses at the site. Data from the 61-meter and 10-meter towers are also transmitted back to the main

site every 15 minutes by telemetry for use in emergency response modeling. The Regional Atmospheric Response Center (RARC) conducts meteorological activities associated with emergency preparedness and response at the site. An upper air remote sensing Sound Detection and Ranging/Radio Acoustic Sounding System (SODAR/RASS) continuously monitors winds, temperatures, and atmospheric stability above the RFETS site.

Through a cooperative agreement with the Colorado Department of Public Health and Environment (CDPHE), meteorological data are transmitted to the site from five surface meteorological stations by telemetry that form a ring around the site perimeter. Another cooperative agreement with NOAA provides near real-time data from multiple monitoring sites throughout the Denver metropolitan area. These data are all received, quality assured, and combined into a three-dimensional observation set for emergency response modeling every 15 minutes, 24 hours per day.

The RARC provides 24-hour consequence assessment support for any unplanned radiological or chemical releases from the site. The Center responds with customized weather forecasts, plume projections, and dose modeling results that lead to event classifications and protective actions for on-site and off-site populations. RARC also conducts specialized consequence assessments in support of emergency preparedness, hazard assessments, and risk assessments for RFETS. Weather forecasts are provided for severe weather events, such as winter storms, windstorms, and severe thunderstorms.

A customized modeling system has been developed and implemented at RFETS to predict the pathway and impacts from any radiological emergency at the site. Called the Computer-Assisted Protective Action Recommendation System (CAPARS), the

new capability addresses the need for fast, accurate plume predictions in a complex atmosphere.

CAPARS provides a variety of plume, weather, hazard, and related products with the accuracy and speed needed for response to an emergency at RFETS. Eleven integrated major subsystems form the overall CAPARS capability.

The State of Colorado has formally accepted the CAPARS modeling system for emergency response and planning applications at RFETS. A specialized planning version of the CAPARS system has been developed, implemented, and applied for emergency planning at the RFETS. Called the TRAC Risk Assessment/Hazards Assessment Model, the capability is designed to support hazards and risk assessments for RFETS and to form the basis for an evaluation of the size and shape of the Emergency Planning Zone (EPZ) surrounding RFETS.

#### Research

There are no current or projected supporting meteorological research activities planned at RFETS.



### SANDIA NATIONAL LABORATORY (SNL)-ALBUQUERQUE

#### Operational

The DOE Kirtland Area Office (KAO) manages SNL in Albuquerque, NM, located between the Rio Grande Valley and Manzano Mountains. SNL covers approximately 80 square miles of flat to mountainous arid terrain. Meteorological Programs at SNL include both support and research activities.

Meteorological services and support are provided through the EOC in the Laboratory Services Division (LSD). The mission is to provide meteorological support for various operations

including:

- Emergency response;
- Environmental surveillance and characterization; and,
- Regulatory compliance.

The monitoring network consists of six 10-meter and two 60-meter towers used to measure wind direction and speed, ambient temperature, and relative humidity. There are also three precipitation gauges, two barometric pressure sensors, and one solar radiation pyranometer in the network.

#### Research

Key research activities are provided through the Energy and Critical Infrastructure Center in the Energy, Information, and Technology Division. SNL scientists are involved in the ARM program and the Surface Heat Budget of the Arctic Ocean (SHEBA). The ARM project is a combined measurement and modeling program. The goal is to gain a better understanding of clouds and their effect on atmospheric radiation, with the final goal of developing better climate models. The SHEBA program addresses the interaction of the surface energy balance, atmospheric radiation and clouds over the Arctic Ocean.

with an adjacent flood plain near the Savannah River. The climate at SRS is typical of the southeastern United States with long, hot and humid summers and short mild winters.

The Atmospheric Technologies Group (ATG) of the Savannah River Technology Center (SRTC) has developed and operated a meteorological monitoring and modeling program at the SRS since the early 1970's. This program supports SRS operations in emergency response consequence assessment, weather forecasting, radiological and non-radiological air quality calculations for regulatory compliance, safety analyses, environmental impacts, engineering studies, environmental research and non-proliferation activities.

ATG's meteorological data sources are extensive and quite varied. Onsite meteorological data are obtained from a network of eight 200-foot meteorological observing towers located near the major production sites. The instrumentation on these towers includes sensitive bi-directional vanes (i.e., bivanes), cup anemometers, resistance thermometers and lithium chloride humidity sensors. Another tower is

rain gauges is located throughout the SRS. Additional local upper-air data are collected from a balloon-launched airsonde system and a portable tether-sonde system. Portable towers are available for use in case studies.

ATG also has access to local radar data, which is then distributed site-wide via the SRS intranet. Regional, national, and international meteorological data are received from a commercial weather data provider via satellite in real time. The data include surface observations, satellite and radar imagery, and predictive model information from the US and abroad.

In addition, ATG has developed the Weather Information and Display (WIND) System as an automated resource for conducting real-time consequence assessments following unplanned releases of hazardous material. The WIND System is a multi-computer platform network that links the real time meteorological observations and forecasts with a suite of atmospheric and aqueous transport and dispersion models. A rolling 24-hour data file is created from data archived in the meteorological database and disseminated to a pc-based workstations that can operate the WIND System's modeling and display software.

In the mid 1990s, a mutual aid agreement with surrounding counties emergency management agencies was created to install and operate four meteorological towers at nearby chemical plants in support of emergency response activities. Data from these towers are incorporated into the SRS meteorological database, integrated into the 24-hour data file, and made available beyond the SRS firewall for use by the off site partner entities using appropriate WIND System software.

Nearby SRS, two television stations, WJBF and WAGT, have built a new television tower, where SRTC has installed meteorological instrumentation at the 100 ft, 200 ft, and 1000 ft levels. This local television transmitter



SAVANNAH RIVER  
SITE (SRS)

#### Operational

The SRS is under the responsibility of the Savannah River Operations Office (SR) and operated by the Westinghouse Savannah River Company (WSRC). SRS is located in southwestern South Carolina, along the banks of the Savannah River. The SRS covers an area of approximately 300 square miles and is thickly forested with pine trees. There are also several small streams, a large swamp, and two reservoirs built as cooling ponds for nuclear plant reactors. The topography of SRS is characterized by gently rolling hills

located at the Central Climatology facility, located near the geometric center of the SRS. It includes like instruments near ground level, 60-ft, 120-ft, and 200 ft. Additional meteorological measurements at the Central Climatology facility include precipitation, evaporation, barometric pressure, soil temperature, solar and long wave radiation. Data are collected with dedicated data loggers at each tower site. Each logger is then polled by a remote computer that, in turn, populates a relational database with meteorological data.

A network of twelve manually-read



tower was instrumented with fast response three-dimensional sonic anemometers and optical water vapor and CO<sub>2</sub> sensors at 100-ft, 200-ft, and 1,000 ft. Slow response temperature and humidity sensors were also installed at these levels. The data from this tower will provide vital information for both operational emergency response and for the USFS to conduct control burns. It will also provide valuable data for research in the atmospheric boundary layer.

A joint partnership between Westinghouse Electric Company and a local television station provides local Doppler radar data to SRS and the local community in real-time. This provides valuable site specific radar returns to assist in site operations. The data (e.g., static and time lapse - movie - images) are available through the site internal computer network at employees' desktop computers.

ATG utilizes a regional mesoscale model, RAMS, for providing detailed forecast information. Specifically, forecasts out to 24 hours from RAMS are available as input for the predictive component of WIND System models. Transport calculations blend observed meteorological data with RAMS forecasts to make timely and accurate assessments. The grid resolution used in RAMS varies from 2 km for the inner grid (100 km x 100 km centered on the SRS) and 8 km for the outer grid (250 km x 250 km).

The SRS Atmospheric Technology Center provides access to local, national and international meteorological data to provide comprehensive meteorological support for SRS and WFO customers. On a daily basis, ATG provides weather forecasts in support of site operations. Typical customers include waste handling groups where wind and rain forecasts often determine daily activities. Also, ATG supports the US Forest Service (USFS) prescribed burn program and site heat stress program with detailed observa-

tions and forecasts. Custom forecasts are also provided to facility and other senior managers to support protective action decisions for severe weather.

#### Research

There are no current or projected supporting meteorological research activities planned at SRS.



### WASTE ISOLATION PILOT PLANT (WIPP)

#### Operational

The Waste Isolation Pilot Plant (WIPP) is operated by Westinghouse TRU Solutions for the DOE Carlsbad Area Office (CAO). A cornerstone of the DOE national clean-up strategy, the WIPP is designed to permanently dispose of transuranic (TRU) radioactive waste generated by defense-related activities in the Salado salt formation 2,150 feet beneath the surface. WIPP is located in Eddy County in southeastern New Mexico, 26 miles east of Carlsbad, and occupies 16 square miles of a region known as Los Medanos. Geographically, the region is regarded as a relatively flat, sparsely inhabited plateau with little surface water.

The WIPP Environmental Monitoring Section (EMS) performs meteorological monitoring as part of the Non-radiological Environmental Monitoring Program. The primary meteorological station provides measurement of wind direction and speed, temperature at two-meters, 10-meters, and 50-meters, as well as ground level measurements of barometric pressure, relative humidity, precipitation, and solar radiation. The main function of the station is to generate data for operational support, emergency response and regulatory dispersion modeling applications. Parameters are monitored continuously and the data are stored in the Central Monitoring Sys-

tem, a computerized system including automated parameter checks, real-time displays in the Central Monitoring Room, and data archiving. Meteorological data are compiled and distributed to stakeholders, including the NOAA NWS, on a monthly basis.

WIPP also, under a cooperative

agreement with the NWS, maintains a Cooperative Weather Observing Station at the Far Field Station. Data from this station are compiled monthly and the Record of Climatological Observations form is submitted to the Weather Forecast Office in Midland, TX. Under the same cooperative agreement, the Midland office is given access to real-time data from the primary meteorological station.

#### Research

There are no current or projected supporting meteorological research activities planned at WIPP.

### WELDON SPRINGS SITE REMEDIAL ACTION PROJECT (WSSRAP)

#### Operational

The activities associated with Weldon Springs Site Remedial Action Project (WSSRAP) have been completed. The meteorological monitoring program that had operated at the WSSRAP since 1994 was dismantled in 2003.

#### Research

There are no current or projected supporting meteorological research activities planned at WSSRAP.

### YUCCA MOUNTAIN PROJECT (YMP)

#### Operational

As part of the DOE Office of Civilian Radioactive Waste Management (OCRWM), the Yucca Mountain Project (YMP) studies may eventually

support a recommendation of Yucca Mountain for the nation's first geologic repository for spent nuclear fuel and other high level radioactive waste (Figure 3-DOE-5). The current meteorological program within the YMP focuses on environmental compliance and operational health and safety considerations, for both employees and the general public.

As with a number of DOE sites, the Yucca Mountain area is one of complex topography and heterogeneous surface characteristics, creating mesoscale conditions that locally influence onsite weather. The YMP meteorological program, therefore, includes four full stations for measuring atmospheric dispersion and general meteorological conditions, as well as nine precipitation stations. These stations serve to monitor the significant variations in airflow, rainfall, and temperature caused by the area's complex terrain environment. The meteorological stations are key to the thorough monitoring of these variations that is essential for the YMP ongoing commitment to environmental compliance and to the health and safety of employees and the public.

The YMP meteorological program also provides essential data for the studies necessary to evaluate the site's suitability for a potential repository. Should the site be deemed suitable and a repository licensed, built, and operated, water would be the primary means by which radioactive materials could be transported to the accessible environment. Thus, movement of water from the atmosphere to the surface and on through the mountain is a key concern. The meteorological program provides essential data for the infiltration model of the mountain. Data about precipitation, humidity, evapotranspiration, surface water run-on, solar radiation, air temperatures, and wind patterns all contribute to the overall infiltration model. The model gives special emphasis to the transient,

or temporal, versus steady-state rates of water movement through the unsaturated zone of rock at Yucca Mountain. The temporal variation of infiltration may be short term, due to weather fluctuations that drive episodic flow, or much longer term, in periods corresponding to climate change. Data from the meteorological program's ongoing monitoring programs are supplemented by the program's paleoclimatology studies. Together, they provide essential information for the YMP modeling of past, present, and future infiltration rates.

If the potential repository were actually built and operated, continuous meteorological monitoring and analysis would also be essential for the operational facilities on the surface of the mountain, at least until the final closure of the repository. Buildings would be built to withstand the probable maximum flood and wind conditions, and administrative controls would be in place to suspend operations during severe weather conditions. An integral part of the emergency response system would include monitoring the overall environmental situation at the repository site.

In turn, an integral part of the overall environmental monitoring system would be the meteorological monitoring system. This system would collect real-time meteorological information about the site and provide weather forecasting and climatological data. Such data would be essential for management decisions regarding the health and safety conditions for employees and the public.

#### Research

There are no current or projected supporting meteorological research activities planned at the Yucca Mountain site.

#### DOE METEOROLOGICAL COORDINATING COUNCIL (DMCC)

Based on a need to facilitate more coordination and cooperation among the meteorological activities at the DOE field offices, the DMCC (i.e., the Council) was established on December 2, 1994. The mission of the Council, now in its eleventh year, is to coordinate meteorological support and research to meet DOE objectives. The objectives of the council are to:

- Promote cost-effective support for all DOE facilities;

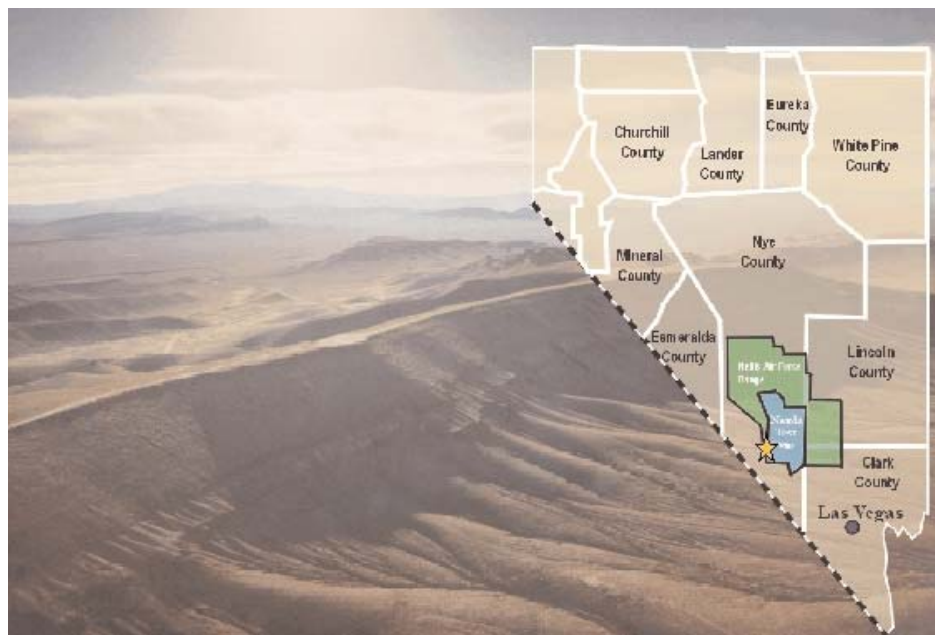


Figure 3-DOE-5. Yucca Mountain (100 miles northwest of Las Vegas, Nevada) is unpopulated land owned by the Federal Government and adjacent to the nation's nuclear weapons test site.

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- Plan for future needs, requirements, and missions;
  - Advocate awareness of atmospheric science applications and benefits to DOE; and,
  - Advocate the use of common methods, procedures, and standards.

Council oversight is provided by a steering committee consisting of DOE and NNSA headquarters and field element representatives. Products of the

DMCC include evaluations of meteorological requirements contained in DOE orders and guidance documents, site meteorological program peer reviews, and, as needed, customized technical assistance. Assist Visits have been conducted at NNSA/NSO, WIPP, Pantex, DOE/OR and SNL-Albuquerque. Two follow-up assist visits were also conducted at WIPP. Additional assist visits are in the planning

stages and will be conducted over the next several years.

The DMCC web page has been broadened and can be accessed at [www.sord.nv.doe.gov](http://www.sord.nv.doe.gov). The DMCC can also be accessed through the web page of the Subcommittee for Consequence Assessment and Protective Actions (SCAPA).